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POTAMOLOGY INVESTIGATIONS

Report 21-5

USE OF PLASTIC FILTER CLOTH IN REVETMENT CONSTRUCTION

POTAMOLOGY RESEARCH PROJECT II

by

B. J. Littlejohn

August 1977

Sponsored by

The President, Mississippi River Commission

and

The Division Engineer
Lower Mississippi Valley Division

Conducted by

U. S. Army Engineer District, Memphis
CORPS OF ENGINEERS
Memphis, Tennessee

POTAMOLOGY INVESTIGATIONS REPORTS

Issued Prior to and Including This Report

Report No.	Title	Date
1-1	Instructions and Outline for Potamology Investigations	November 1947
1-2	Outline of Plans for the Potamology Investigations	December 1947
2-1	Preliminary Flume Tests of Mississippi River Revetment (1st Interim Report)	October 1947
2-2	Preliminary Tests of Mississippi River Dikes, Bank Stabilization Model	June 1950
2-3	Preliminary Tests of Experimental Baffles, Bank Stabilization Model	September 1951
2-4	Preliminary Flume Tests of Mississippi River Revetment (2d Interim Report)	November 1951
2-5	Investigation of Bank Stabilization, Miller Bend, Mississippi River	April 1953
2-6	Verification of Bank-stabilization Model	July 1953
3-1	Preliminary Laboratory Tests of Sand-asphalt Revetment	July 1948
5-1	Geological Investigation of Reid Bedford Bend Caving Banks, Mississippi River	July 1947
5-2	Field Investigation of Reid Bedford Bend Revetment, Mississippi River (3 volumes)	June 1948
5-3	Reid Bedford Bend, Mississippi River, Triaxial Tests on Sands	May 1950
5-4	Piezometer Observations at Reid Bedford Bend and Indicated Seepage Forces	May 1950
5-5	Standard Penetration Tests, Reid Bedford Bend, Mississippi River	May 1950
5-6	Undisturbed Sand Sampling and Cone Sounding Tests, Reid Bedford Bend Revetment, Mississippi River	May 1951
7-1	Soils Investigation, Bauxippi-Wyanoke Revetment	June 1951
8-1	Hardscrabble Bend, Mississippi River, Revetted Bank Failure, Soils Investigation	June 1950
9-1	Bank Caving Investigations, Kempe Bend Revetment, Mississippi River	November 1951
10-1*	Preliminary Development of Instruments for the Measurement of Hydraulic Forces Acting in a Turbulent Stream	June 1948
10-2	Turbulence in the Mississippi River	May 1950
10-3*	Evaluation of Instruments for Turbulence Measurements, 1948-1949	March 1951
10-4*	Evaluation of Instruments for Turbulence Measurements, 1949-1950	April 1951
11-0	Résumé of Conference Initiating Potamology Investigations, 11 February 1947	February 1947
11-1	Report of Conference on Potamology Investigations, 15 March 1948	March 1948
11-2	Report of First Potamology Conference with Hydraulics Consultants, 9-10 December 1948	December 1948
11-3	Minutes of Conference on Soil Studies, Potamology Investigation, 18 April 1949	April 1949
11-4	Report on Second Potamology Conference with Hydraulics Consultants, 23-24 May 1949	May 1949
11-5	Minutes of Conference with Soils Consultants, Stability of Mississippi River Banks, 5-8 October 1949	October 1949
11-6	Report of Conference on Potamology Investigations, 6-7 October 1949 (Volume 1, Volume 2*)	April 1951
11-7	Minutes of Conference on Soil Aspects of Potamology Program, 17-18 June 1950	October 1950
11-8	Minutes of Potamology Conference, 5 April 1951	April 1951
12-1	Density Changes of Sand Caused by Sampling and Testing	June 1952
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12-3	Verification of Empirical Method of Determining Slope Stability	April 1954
12-4	Verification of Empirical Method of Determining Slope Stability - 1954 Data	June 1955
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13-1	Bank Caving Investigations, Huntington Point Revetment, Mississippi River	June 1952
14-1	Goodrich Landing Revetment, Mississippi River, Field Investigation	June 1952
15-1	Bank Caving Investigations, Free Nigger Point and Point Menoir, Mississippi River	May 1952
16-1	Development of Operating Technique for and Verification of Channel-meander Model	September 1953
17-1	Hydrographic and Hydraulic Investigations of Mississippi River Revetments	April 1954
18-1	Rotary Cone Penetrometer Investigations	June 1962
18-2	Verification of Cone Criteria for Determining Riverbank Stability	June 1965
19-1	Hydraulic Analysis of Mississippi River Channels, Miles 373 to 603, Fiscal Year 1964	September 1965
19-2	Resume of Research Studies of Hydraulic Characteristics of Mississippi River Channels, Interim Report FY 1967, Research Project 10	April 1967
19-3	Hydraulic Characteristics of Mississippi River Channels, Interim Report, FY 1970	June 1970
20-1	Effects of River Stages on Bank Stabilization; Analysis of Field Data	December 1965
21-1	Sand-Filled Bags as Dike Material; Potamology Research Project 9	March 1967
21-2	Review of Past Experience with Contraction Works; Potamology Research Project 9	March 1967
21-3	Investigation of Existing Dike Systems; Potamology Research Project 9	May 1969
21-4	Use of Plastic Filter Cloth in Revetment Construction; Potamology Research Project 11	June 1970
21-5	Use of Plastic Filter Cloth in Revetment Construction, Potamology Research Project 11	August 1977

* Not of general informational value and hence not distributed.

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POTAMOLOGY INVESTIGATIONS

Report 21-5

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USE OF PLASTIC FILTER CLOTH IN REVETMENT CONSTRUCTION

POTAMOLOGY RESEARCH PROJECT 11.

by

10 B. J. Littlejohn

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The President, Mississippi River Commission

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FOREWORD

This report is submitted in connection with Potamology Research Project No. 11, conducted by the Memphis District, Corps of Engineers, by direction of the Lower Mississippi Valley Division Potamology Board. This study is a follow-up to an earlier study made to determine the feasibility of using plastic filter cloth as a substitute for the standard gravel blanket used in revetment construction. The results of that study are published in Report 21-4, Use of Plastic Filter Cloth in Revetment Construction, dated June 1970. The difficulty encountered in placing the cloth on the underwater slope led to this study to determine whether the cloth could be placed by sinking as a part of the revetment mattress. This report includes the results of experimental installations of the filter cloth in revetment construction at Island 40, Tennessee, in 1968 and at Hickman-Reelfoot, Kentucky, in 1969. The project was proposed at the Twenty-First Potamology Conference on 21 November 1967 and approved by the Potamology Board in paragraph 30 of the minutes of that meeting.

The study was conducted by Mr. B. J. Littlejohn under the supervision of Mr. C. L. Curry and the general direction of Messrs. J. L. Hyde and A. C. Michaels, Engineering Division. The field work was coordinated and documented by Messrs. J. H. Bowman and D. L. McNutt and the report was prepared by Mr. B. J. Littlejohn.

Colonel Charles T. Williams, CE, Colonel John V. Parish, Jr., CE, Colonel A. C. Lehman, CE, and Colonel Robert W. Lockridge, Jr., CE, were District Engineers during the conduct of the study and the preparation of this report.

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SUMMARY

This study is part of a program of general investigations for improving the design of stabilization structures on the lower Mississippi River. Many revetment failures occur each year as a result of the subgrade material being eroded through the voids of the articulated concrete revetment mattress. The process of erosion frequently continues until an extensive scour pocket develops beneath the mattress. This can eventually result in a structural failure in the mattress or progressive movement toward the bank and in either case poses the threat of a bank failure. There are some locations where a failure could not be tolerated because of the possible danger to life and property that might result. This stresses the need for providing a greater degree of protection at such locations by modifying the standard revetment design. In recent years, woven cloths have proven very effective in controlling erosion. Limited experiments were first conducted by this District in 1965 in placing woven filter cloth in revetment construction. This study is an extension of those experiments with the objective of determining the feasibility of placing the cloth on the underwater subgrade by attaching the cloth to the mattress squares during casting operations and sinking the unit as a part of the revetment mattress.

This report presents a description of the construction procedures and the results of two experimental installations of the cloth. In August 1968, 444 squares were placed at Island 40, Tennessee, with the filter cloth bonded to the bottom sides of the mattress squares using two types of seams previously tested in the laboratory. These did not provide a completely satisfactory bond as the cloth pulled completely

loose from seven squares and partially loose from numerous others. As a secondary objective, annual surveys were made to evaluate the performance of this test section against adjacent sections of mattress underlain with the standard gravel blanket, but over the last several years a fill has deposited over the test reach, thus preventing further comparisons. In September 1969, 48 squares were placed at Hickman-Reelfoot, Kentucky, to test two variations of a different type of bonding device consisting of one-quarter inch cords sewn on top of the strips of cloth.

In general, the experiments showed that the cloth can be satisfactorily placed on the underwater subgrade by bonding the cloth to the bottom of the mattress squares. The cords sewn on top of the cloth in Experiment No. 2 provided better bonding qualities than the sewn seams used in Experiment No. 1. The cost of mattress in place with the filter cloth attached would be increased by about 25 percent over the cost of standard mattress. However, the use of filter cloth bonded to the mattress squares is recommended for consideration when the requirement for a more effective bank protection at certain locations warrants the additional cost, and particularly in cases where a bank failure would be crucial.

POTAMOLOGY INVESTIGATIONS

USE OF PLASTIC FILTER CLOTH IN REVETMENT CONSTRUCTION

POTAMOLOGY RESEARCH PROJECT 11

BACKGROUND

1. Revetments have been a valuable tool in developing the Lower Mississippi River for navigation and flood control. In the master plan for stabilizing the Lower Mississippi, revetments are used extensively to hold the channel in a desired alignment by preventing bank caving and controlling channel meandering.

2. The construction of a revetment consists mainly of grading the river bank to a stable slope and then covering the bank with an armor of stone, concrete, or other materials resistant to current and wave action. The articulated concrete mattress used for the underwater portion of the bank and the riprap stone used for the upper bank have evolved as the present standard for bank protection on the lower river. This mattress is made up of units 4 feet wide and 25 feet long, consisting of twenty concrete blocks, 3 inches thick, connected with a corrosion resistant wire fabric. These mattress units are commonly referred to as squares (100 sq. ft.) and are precast on land and transported by barge to the site for assembly and sinking. They are placed by a highly specialized plant developed for the Lower Mississippi River.

3. The space between the individual concrete blocks is about 5/8-inch and the longitudinal space between adjacent squares is about 1-3/4 inches. These openings perform two important functions: (1) permit sufficient drainage from the bank to prevent the build-up

of destructive hydrostatic pressures and (2) provide flexibility of the mattress to conform to the natural irregularities of the river bank and changes which occur from subsequent loss of material from beneath the mattress. While these openings in the mattress have a definite purpose, they also create a weakness in the bank protection. The openings in a revetment mattress amount to about 8 percent of the total area. The loss of subgrade material through the mattress due to current and wave action is considered to be the primary cause of most revetment failures. This in turn results in large expenditures for revetment maintenance.

PURPOSE AND SCOPE

4. The purpose of the study was to determine by full-scale field experiments the feasibility of placing filter cloth on the underwater subgrade by bonding the cloth to the mattress squares during the casting operation and sinking as part of the normal construction operation. The experiments were intended primarily to test this method of placing the cloth. For this reason, the limits of the filter cloth would be the same as the mattress limits rather than the limits of the blanket material. A secondary purpose was to make a general evaluation of the performance of the mattress underlain with the cloth in relation to that of standard revetment mattress where possible.

5. Two separate experiments were conducted, the first in 1968 involving 444 squares and the second in 1969 involving 48 squares. This report presents the details of construction and the results of the two experiments, hereafter referred to as Experiment No. 1 and Experiment No. 2, which are covered in subsequent sections of the report.

BLANKET MATERIALS PRESENTLY USED

6. A layer of material, commonly called a blanket, is placed in a strip along the bank after grading is completed. Its primary purpose is to provide interim protection to the bank against the erosive action of the current, waves, and propeller wash during the one-to-two week period between the bank grading and mattress sinking operations. The blanket serves a secondary purpose in providing additional protection against erosion in the zone of connection between the mattress and the stone paving where many failures occur. The most commonly used blanket materials are river-run gravel, crushed stone, and shell. This is because of the nominal cost and availability in large enough quantities to support the revetment construction operation.

7. The width of the blanket is determined by the type of soil in the bank. On sandy banks, the blanket is extended to the top of the bank. On banks of less erodible soils such as silts or other fine grained deposits, the blanket is extended from about mid-bank to about 10 feet vertically below the water elevation, which covers the area of the most critical erosion. The blanket is placed 4 inches in thickness above the water surface and at the rate of 2.5 tons per square (100 sq. ft.) below the water surface, which if evenly distributed, would amount to a thickness of 6 inches. Because of the difficulty involved in underwater placement, no blanket is provided under the remaining portion of the mattress.

8. Even with the blanket, undermining of the inshore portion of the mattress still occurs at some locations. One solution to this

problem in past years has been to fill the openings in the portion of the mattress exposed during low river stages with a sand-cement or sand-asphalt grout. However, this adversely affected both the flexibility and permeability of the mattress. Furthermore, the cost became prohibitive and this practice was discontinued. At locations where the mattress was placed some distance above the low water elevation because of high river stages at the time of placement, repair costs have been extremely high, particularly on sandy banks.

PLASTIC CLOTH AS EROSION PROTECTION

9. The increasing use of synthetic filters for erosion control prompted a study which was initiated in 1965 by the Memphis District to compare the relative merits of a woven plastic cloth to those of the standard gravel blanket presently used. The results of the study are reported in Potamology Investigations Report 21-4, dated June 1970, which included a comparison of the effectiveness and cost of the two materials. It was found in that study that the cloth was superior to gravel in retaining subgrade material under the articulated concrete mattress. However, one main drawback to using the cloth was that there was no mechanical means of placing and holding the cloth on the underwater subgrade in the swift and turbulent current usually encountered in revetment construction. This required hand placing which limited the depth of placement to about 4 feet.

10. Because of this difficulty in placing and anchoring the filter on the underwater slope, an idea was advanced to attach the filter cloth to the bottom of the mattress squares during the

casting operation. The filter would then be laid simultaneously with the mattress, thus eliminating the underwater placing and anchoring problem. This idea led to an experiment to explore the possibilities of casting and sinking articulated concrete mattress with the filter cloth attached.

11. The earlier study involved the placement of cloth over about the same limits where gravel, crushed stone, or shell is normally placed in order to make a direct comparison between the two types of material. In this study, the cloth would extend over the entire limits of the articulated concrete mattress, insofar as possible, within the test reach. This was considered necessary to evaluate this method of placement under various depth and current conditions, particularly in deep water.

DESCRIPTION OF THE CLOTH

12. The synthetic material selected for this experiment is known as Poly-Filter X, manufactured by Carthage Mills Incorporated, Cincinnati, Ohio. The material is a cloth woven of polypropylene monofilament yarns. This fabric has been used successfully in numerous structures for bank erosion protection on coastal and inland waterways both in Europe and the United States.

13. The filter cloth was ordered in a 50-inch width to extend about 2 inches beyond the edge of the concrete mattress on each side. The width of the mattress square is 46-1/4 inches and the longitudinal space between adjacent squares is 1-3/4 inches. Since the cloth on each of the two adjacent squares would extend over the space, one

overlapping the other, this space would be covered by two layers of filter cloth. This would provide an extra margin of safety to insure that the cloth would extend over the full area of the mattress.

EXPERIMENT NO. 1:

SELECTION OF THE BONDING DEVICE

14. The first problem to be solved was that of finding some means of fastening the filter cloth to the concrete mattress. After considering several possibilities, it was decided to incorporate a raised seam in the cloth to form a protrusion which would be imbedded in the concrete mattress during the casting operation. The idea was simple but the seam would have to be devised within two basic constraints. The first was that the seam would have to protrude far enough to become firmly imbedded in the concrete. The second was that the seam would have to be either sufficiently small or compressible to prevent raising the steel mattress forms excessively because the casting contractor is paid on the basis of a theoretical volume of concrete placed. Any increase in the quantity of concrete required to fill the forms could possibly be the basis for a claim by the contractor. Samples of cloth with two types of raised seams, located 6 inches from the longitudinal edges of the cloth strip, were supplied by the manufacturer. One type of seam consisted of a 1/8-inch hollow polyethylene cord which was inclosed and sewn into a fold of the cloth. The other consisted of a double fold in the cloth sewn in place. Small scale laboratory tests were conducted by casting individual concrete

blocks to determine the bonding qualities of each seam (Photo 1). These tests indicated that the seam with the cord sewn in furnished a more satisfactory fastening device than did the seam with the fold sewn into the cloth. But since the laboratory tests were of such limited scale, it was decided to cast 407 squares of mattress using the cord seam and 37 squares using the folded seam to test both types under actual field conditions.

CASTING THE MATTRESS

15. The experimental mattress squares were cast at Richardson Landing Casting Field, Tennessee, during the period 6-21 May 1968. The operation was conducted in conjunction with the mattress casting contract, which was modified to incorporate the casting of 444 squares of mattress with the filter cloth bonded to the bottom side.

16. The normal casting procedure is outlined as follows: (1) kraft paper is placed on the ground and on successive layers of mattress, (2) the wire fabric is placed in the forms, (3) the forms are set in position on the kraft paper and the fabric positioned in the forms, (4) the concrete is placed in the forms, (5) the concrete is finished, and (6) the forms are removed after initial set of the concrete. The mattress is cast in stacks 12 squares high and the ends of the stacks are normally spaced 10 inches apart. Casting of the experimental mattress required a slight alteration of the normal casting procedure to include two additional steps. After the kraft paper was placed, step (1) above, the filter cloth was placed on top of the paper with

the seams on the top side (Photo 2). The cloth was supplied in rolls 470 and 495 feet long, and placed in continuous runs to cover 18 and 19 stacks, respectively, for a complete row of 37 stacks. This required that the cloth between the ends of the squares be cut after the concrete had set (Photo 3). The mattress stacks were spaced 5 inches apart at the ends rather than the usual 10 inches to minimize waste of the filter cloth. The cloth was cut nearly flush with the ends of the squares to prevent the excess cloth from interfering with tying the three wires at the ends of the squares during assembly of the mattress. Since the maximum space between the ends of the squares after assembly is only 1/2-inch, this did not materially affect the filter coverage.

17. The above procedure was used in casting the first eleven layers of the experimental mattress. In the twelfth and final layer, the kraft paper was omitted to determine whether the filter cloth would perform the function of the paper, that of preventing a cement bond from forming between successive layers of mattress as the squares were cast on the stack. Since laboratory tests indicated that some bonding would occur when only the filter cloth separated two adjacent squares, a film of oil was sprayed on the surface of the eleventh layer to minimize this problem.

18. Upon unrolling the cloth with the polyethylene cord sewn in, there was a crease in the cloth parallel to the cord which could not be eliminated without delaying the casting operations (Photo 4). This reduced the effective width of the cloth as much as two inches in some

places and allowed the cloth to extend only one inch at these locations rather than the desired two inches on each side of a square. In placing the forms on the filter cloth, care was exercised to position the forms so that an equal width of cloth protruded on each side. Even the rolls with the folded seams sewn into the cloth had some creasing, but to a lesser extent.

SITE OF THE EXPERIMENT

19. The site selected for placement of the experimental mattress was Island 40, Tennessee, about 12 miles upstream from Memphis where the existing revetment was to be extended upstream during the 1968 construction season to prevent caving along the west bank of the Mississippi River at mile 747 AHP. This location was selected so that the test section could be placed on a sandy bank where it would be susceptible to erosion of material through the openings of the mattress.

20. The revetment design included articulated concrete mattress extending from an elevation of about +5 ALWP (5 feet above the average low water plane) to a depth of 35 feet at the toe of the slope, for an inshore to outshore width of about 275 feet. Riprap stone paving was specified from the inshore edge of the mattress to the top of the bank. A gravel blanket was also specified to extend from +15 ALWP, or approximate mid-bank, down the slope to a point 10 feet vertically below the water surface. The test squares were to be placed in two mattresses between ranges 122+25 and 124+95 as part of the 2,320-foot upstream extension of the revetment (Plate 1). One full mattress, 135 feet by 275 feet, would be assembled from 385 of the test squares. The remaining

59 squares would be placed in the first two launches or the inshore 50 feet, of the next mattress upstream.

MOVEMENT TO THE MATTRESS BARGE

21. On 22 August 1968, the experimental mattress was moved from the casting field to a barge for transporting later to the work site at Island 40 Revetment. The mattress was picked up in stacks of 12 squares by a crane with a lifting frame and loaded onto a low-bed truck. It was then hauled to the riverbank where it was moved in the same manner from the truck to the barge (Photo 5). All of the 444 experimental squares were loaded on one barge. The entire loading operation was accomplished without any alteration of the normal handling procedure and no additional time was required to handle and load the experimental mattress. During the moving operation, only one instance was noted where the filter cloth came loose from one of the mattress squares.

PLACING THE MATTRESS

22. The experimental mattress squares were placed at Island 40 on 28 August 1968. The sinking operation proceeded without difficulty, except for an initial slowing of production until the crane operators became accustomed to the experimental mattress.

23. The two-square pick-up frames, which are used in moving the mattress from the supply barges to the mat deck on the sinking plant, were used successfully in picking up and handling the test squares (Photo 6). The pick-up frame is equipped with a set of alternating short and long points, each with air-activated fingers to hook the

wire fabric protruding on each side of the squares. The short points lift the top square as the long points lift the bottom square. To pick up two of the test squares, it was necessary for the long points to pierce the filter cloth protruding outward between the two squares in the area of the scarf box to pick up the lower square, but this proved to be no problem. Also, there were no serious problems in separating the mattress squares where the kraft paper had been omitted between the eleventh and twelfth layers on the stacks at the casting field.

24. Assembly of the test squares in the mattress was done in the same manner as with standard mattress squares. Most of the wire tying was done manually and proceeded at a normal rate. One automatic tying tool was being tested in a separate experiment to determine its feasibility in lieu of manual tying, which became the standard method for tying in 1970 (Photo 7). It was used successfully in tying some of the test squares, with no malfunctions or delays due to the underlying filter cloth. It had been anticipated that the portion of the cloth extending beyond the sides of the squares might interfere with the operation of the tool, but this was not the case.

25. Each launch was closely observed as it moved down the mat deck and into the water to determine whether the filter cloth was still attached to the bottom of the mattress squares (Photo 8). The cloth on seven squares was pulled loose from the concrete mattress to such extent that it would be of little or no value as erosion control.

Several more squares had portions of the cloth pulled loose to the extent that the filter coverage provided as the mattress squares were being placed on the underwater subgrade was questionable. Numerous other squares had one or more corners pulled loose from the mattress. Since most of the cloth strips were pulled loose as the mattress was being launched from the sinking plant, a breakdown of the bonding failures between the two types of seams could not be made.

26. There was some concern that sinking the experimental mattress might present a problem because of the substantial reduction in permeability of the mattress due to the attached filter cloth. There have been instances where a complete mattress has been overturned by the tremendous forces of the current during the sinking operations. However, no difficulty was experienced and the experimental mattress sank as smoothly as standard mattress. Surface velocities of the current measured at the inshore and outshore ends of the mattress were 3.9 and 4.7 feet per second, respectively, generally representing normal flow conditions.

27. The fact that the two types of seams used in this experiment did not provide a completely satisfactory bond led to a second experiment to test a different type of bonding device, which is described in the next section as Experiment No. 2.

EXPERIMENT NO. 2

THE BONDING DEVICE

28. After being advised of the failures in the bonding devices used in the first experiment, Carthage Mills, Incorporated, furnished two samples with a cord sewn directly on top of the cloth. They had continued attempts to develop a more satisfactory bonding device even before the first experiment was conducted. This type of bonding device had a major advantage over the two previously used in allowing the cloth to extend the full two inches beyond the edge of the mattress on each side since the entire 50-inch width of the cloth laid flat with no folds or creases (Photos 9 and 10). Both samples of cloth had a 1/4-inch diameter cord sewn on top, but one was polyethylene and the other cotton. These were located six inches from and parallel to the two longitudinal edges, the same as for the previously used seams.

CASTING THE MATTRESS

29. The experimental mattress squares were cast at Cates Casting Field, Tennessee, on 20-22 May 1969, in conjunction with the standard mattress casting contract which was modified to incorporate the casting of 48 squares of mattress with the filter cloth bonded to the bottom side. The casting procedure was the same as that used in Experiment No. 1. Of the 48 test squares, 24 were cast using the polyethylene cord and 24 were cast using the cotton cord. The corners of the test squares were painted with red or black paint for easy identification of the two types of cord during the handling, assembling, and sinking operations.

MOVEMENT TO THE MATTRESS BARGE

30. On 16 September 1969, the test squares were moved from the casting field to a mattress barge for shipment to the sinking site. The squares were loaded in the same manner as in Experiment No. 1 and none of the cloth strips came loose during the loading operation.

PLACING THE MATTRESS

31. The site selected for placing the 48 test squares was Hickman-Reelfoot Revetment, about six miles downstream from Hickman, Kentucky. The revetment was to be extended 5,960 feet downstream along the east bank at mile 916 AHP. Because of the small number of squares involved, performance of the test squares was not a consideration in this experiment. The only objective was to determine the adequacy of the cords in bonding the filter cloth to the mattress squares.

32. The test squares were placed on 22 September 1969, in one mattress between ranges 317+70 and 318+30. They were arranged 15 abreast in each of the first three launches, with the remaining three arranged abreast in the fourth launch. There were no requirements for separating the test squares according to the type of cord used. As in experiment No. 1, there were no difficulties in sinking the 48 squares.

33. The cords sewn on top of the filter cloth definitely provided a more satisfactory bond than the seams used in Experiment No. 1. However, the use of the cords did not completely eliminate bonding failures between the filter cloth and mattress. As the mattress units were being handled and assembled on the deck of the sinking plant, one square had the cloth pulled loose from a part of one side and another

had the cloth pulled loose from a small area in one corner. On both squares where these partial failures were observed, the cotton cord had been used. No failures were observed on squares where the polyethylene cord was used as the bonding device.

COSTS

34. This means of placing the filter cloth on the underwater subgrade involved simply an alteration of the existing method of casting articulated concrete mattress. Therefore, the only meaningful cost is the additional amount required for the purchase and installation of the filter cloth in the casting operation. No additional costs were included for sinking because there was no discernible difference in the handling, assembling, and launching of the test squares and standard mattress squares. No savings were claimed for eliminating the Kraft paper because the oil spray treatment required would probably offset this savings.

35. For Experiment No. 1, the cost of the cloth amounted to $13.69 per square and the additional cost for casting the mattress with the filter cloth attached amounted to about $0.10 per square for a total in-place cost of $13.79 per square. For Experiment No. 2, the cost of the cloth amounted to $14.32 per square and the additional cost for casting was $0.10 per square for a total in-place cost of $14.42 per square.

DISCUSSION

36. Both of the experiments were considered successful from a construction standpoint. The great majority of the test squares were

cast and placed in a satisfactory condition. Also, there were no unusual problems encountered during the course of the two experiments.

37. Casting the articulated concrete mattress with the filter cloth attached to the bottom side and sinking it as an integral part of the mattress is a means by which revetments can be constructed to provide a greater degree of protection against the erosive forces of the river. The filter cloth has been shown in previous tests to be superior to gravel as a filter, but until now, there has not been a suitable method available for placing and holding the filter cloth on the underwater subgrade. This method eliminates hand placement of the cloth and in the case of Island 40 was placed to a depth of 35 feet with no problems. Placement to greater depths may be possible but this can be determined only by further tests. No ballasting is required to anchor the cloth in place since it is directly under the mattress.

38. At the same time, there are several inherent disadvantages to this method of placing the filter cloth. The major one is that the need for gravel is not eliminated since the graded bank must be protected during the interim period between the grading and sinking operations. The quantity of gravel could probably be reduced by the requirement for less extensive coverage, but not eliminated. If the coverage of the filter cloth were limited to the inshore 25-50 feet where gravel is usually placed, the requirement for shuttling mattress barges with the two types of mattress would reduce the efficiency of the sinking operations, resulting in a higher sinking cost.

39. Placement of the filter cloth over the entire mattress area as was done in Experiment No. 1 is considered practical from a construction standpoint and could conceivably be economically feasible in some cases. At locations where problems with bank failures can be anticipated because of severe current attack, highly erodible soils, or other adverse conditions, the extra degree of protection provided by the filter cloth may be warranted. It is quite likely that the reduction in maintenance costs would in many cases be substantial enough to more than offset the additional cost of the filter cloth, depending on individual site conditions. In other cases where a bank failure would threaten life or property by the loss of flood control structures or other critical works, this method should be given strong consideration. Economics is not the primary consideration in such cases and the best possible bank protection must be provided.

40. Although performance of the cloth was of secondary importance in this experiment, surveys have been made annually at the Island 40 site to determine any differences in the scour pattern in the areas of the filter cloth and the adjacent standard mattress. Since construction, however, a fill ranging in depth from 1 to 3 feet has deposited over the entire test reach thus preventing any type of comparison. The test area at Hickman-Reelfoot was considered too small to make any meaningful comparisons.

41. It is important that the filter cloth selected for a given site have openings small enough to effectively retain the subgrade material. At the same time, it is equally important that the cloth

have sufficient permeability to provide free drainage to prevent the buildup of a hydrostatic head. With the many types and variations of synthetic filter materials presently on the market and new ones being developed continuously, the designer has a wide range from which to choose to meet his particular needs. The type of soil comprising the bed and banks of the site should be considered along with drainage and ground water conditions. The velocities of the current, angle of attack, and the hydrographic cycle are other factors to consider. However, it must also be considered from a practical view that the more types of cloth that are used, the more complicated the logistics problem becomes. The use of any mattress underlain with filter cloth will require shuttling of mattress supply barges since it is not feasible to use the mattress with attached filter cloth exclusively. The use of more than one type of cloth or fabric will simply compound the problem.

CONCLUSIONS

42. From the two experimental installations of the filter cloth at Island 40 and Hickman-Reelfoot, it was concluded that:

a. Bonding the cloth to the bottom of the mattress squares does offer a satisfactory means of placing and anchoring the cloth on the underwater subgrade to a depth of at least 35 feet.

b. The 1/4-inch cords sewn on top of the filter cloth as used in Experiment No. 2 provide better bonding qualities than the folded and sewn seam of the types used in Experiment No. 1.

c. This method does not eliminate the need for gravel in revetment construction, although it would probably reduce the quantity required.

d. The cost of mattress in place would be increased by about $14.00 per square, which is about 25 percent over the 1968-69 cost.

RECOMMENDATIONS

43. The following recommendations are made relative to the installation of filter cloth as part of the mattress casting and sinking operations:

a. That this method be considered as a means for providing a more effective bank protection at locations where the need for such a degree of protection warrants the additional cost or where a bank failure would be critical.

b. That the 1/4-inch polyethylene or similar cords sewn directly on top of the cloth strips be used as the bonding device.

c. That a cloth be selected that will provide the optimum retention and permeability properties required for a particular site.

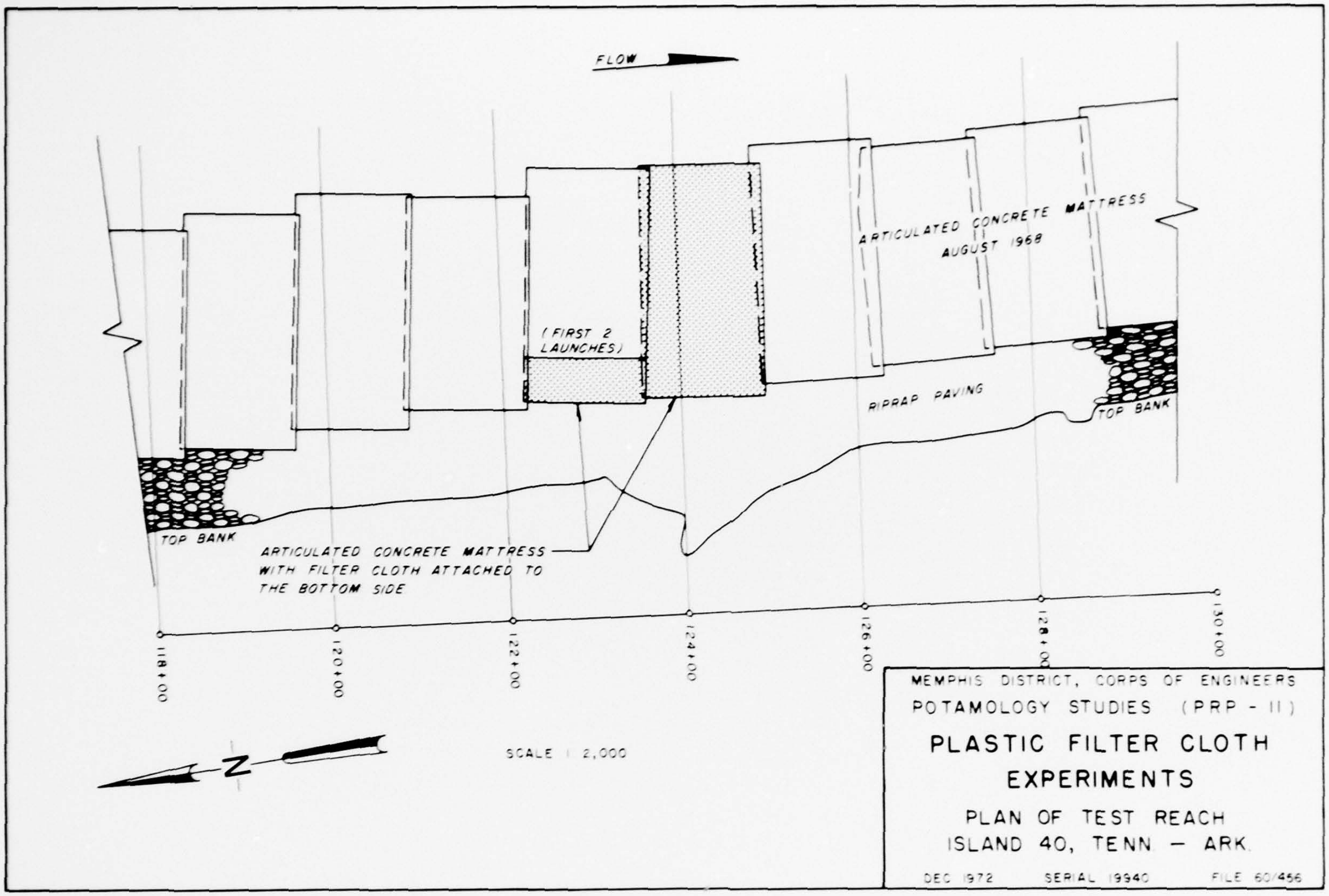
FLOW
ARTICULATED CONCRETE MATTRESS
AUGUST 1968
(FIRST 2
LAUNCHES)
RIPRAP PAVING
TOP BANK
TOP BANK
ARTICULATED CONCRETE MATTRESS
WITH FILTER CLOTH ATTACHED TO
THE BOTTOM SIDE
118+00
120+00
122+00
124+00
126+00
128+00
130+00
N
SCALE 1:2,000
MEMPHIS DISTRICT, CORPS OF ENGINEERS
POTAMOLOGY STUDIES (PRP - 11)
PLASTIC FILTER CLOTH
EXPERIMENTS
PLAN OF TEST REACH
ISLAND 40, TENN. - ARK.
DEC 1972
SERIAL 19940
FILE 60/456

PLATE I

Photo No. 1

Casting concrete mattress blocks on filter cloth in laboratory tests to evaluate the bonding qualities of raised seams. Note the seam in the right center of photo.

Photo No. 2

Filter cloth being unrolled on top of the kraft paper in preparation for casting the first layer of mattress in the stack.

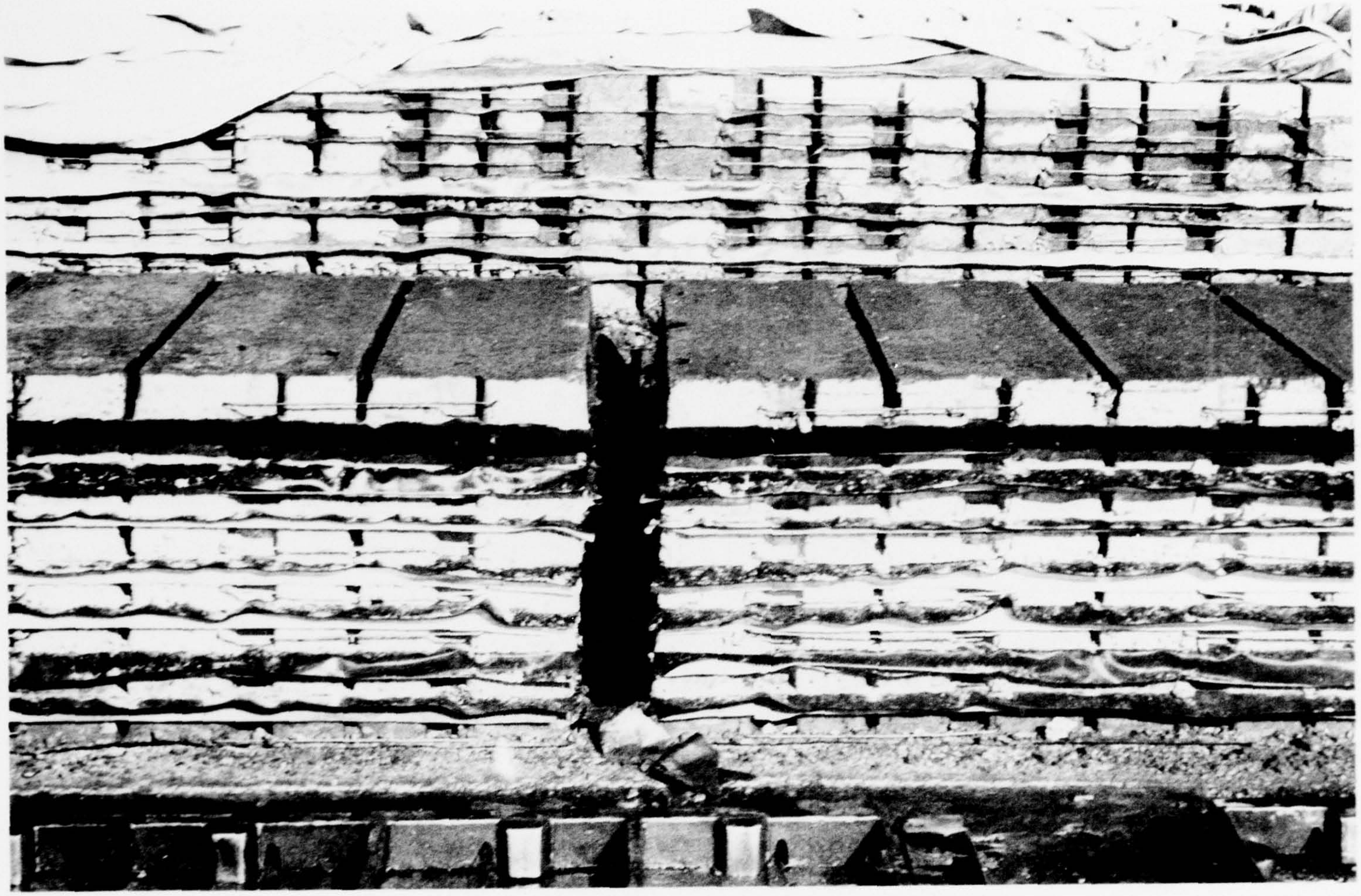

Photo No. 3

Stacks of mattress with filter cloth. The connecting length of cloth between the ends of the squares has been trimmed.

Photo No. 4

A folded crease parallel to the raised seam was inadvertently left in the cloth during the manufacturing process. This reduced the effective width of the cloth strip.

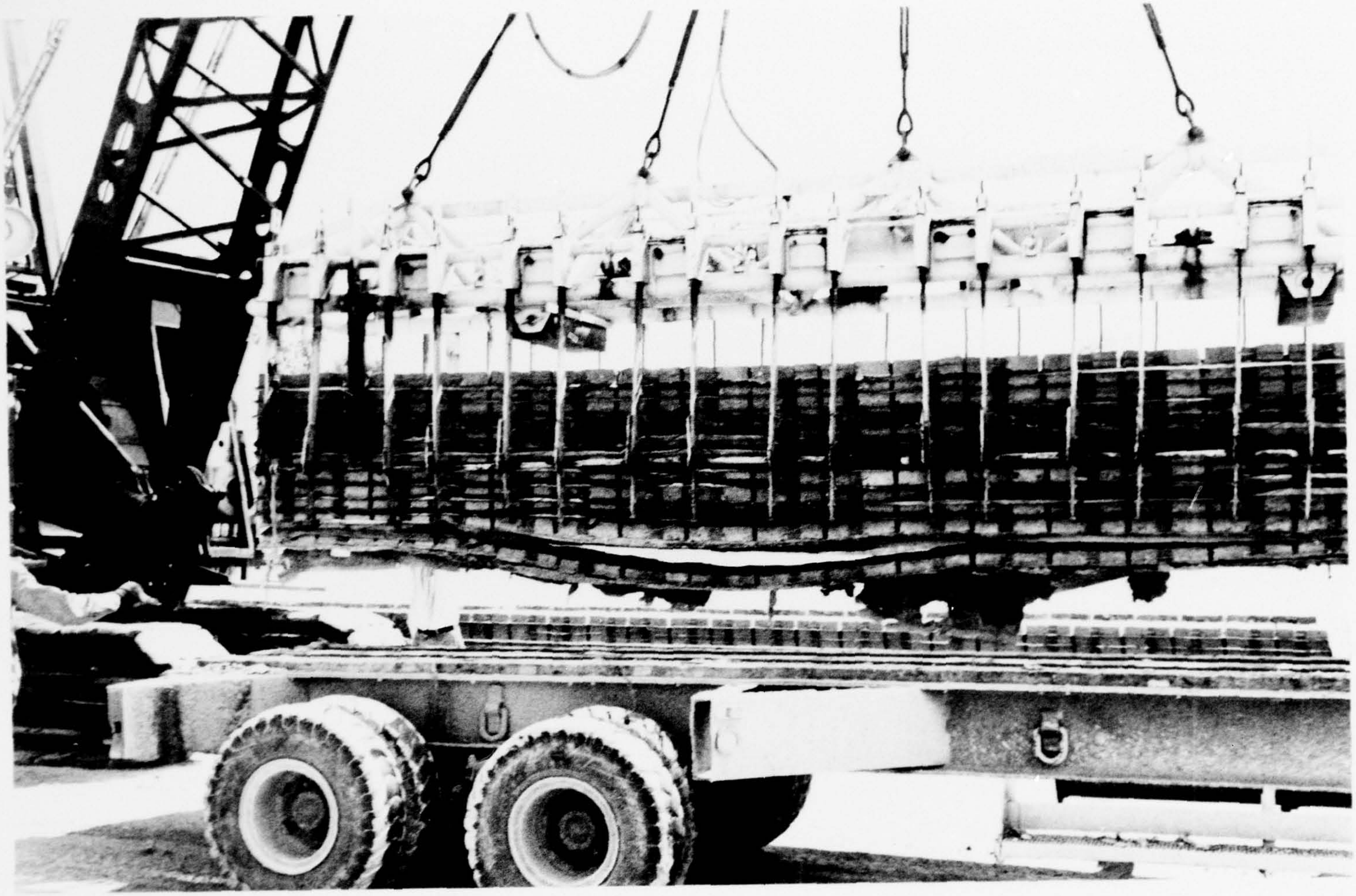

Photo No. 5

Mattress with filter cloth being loaded at the casting field.

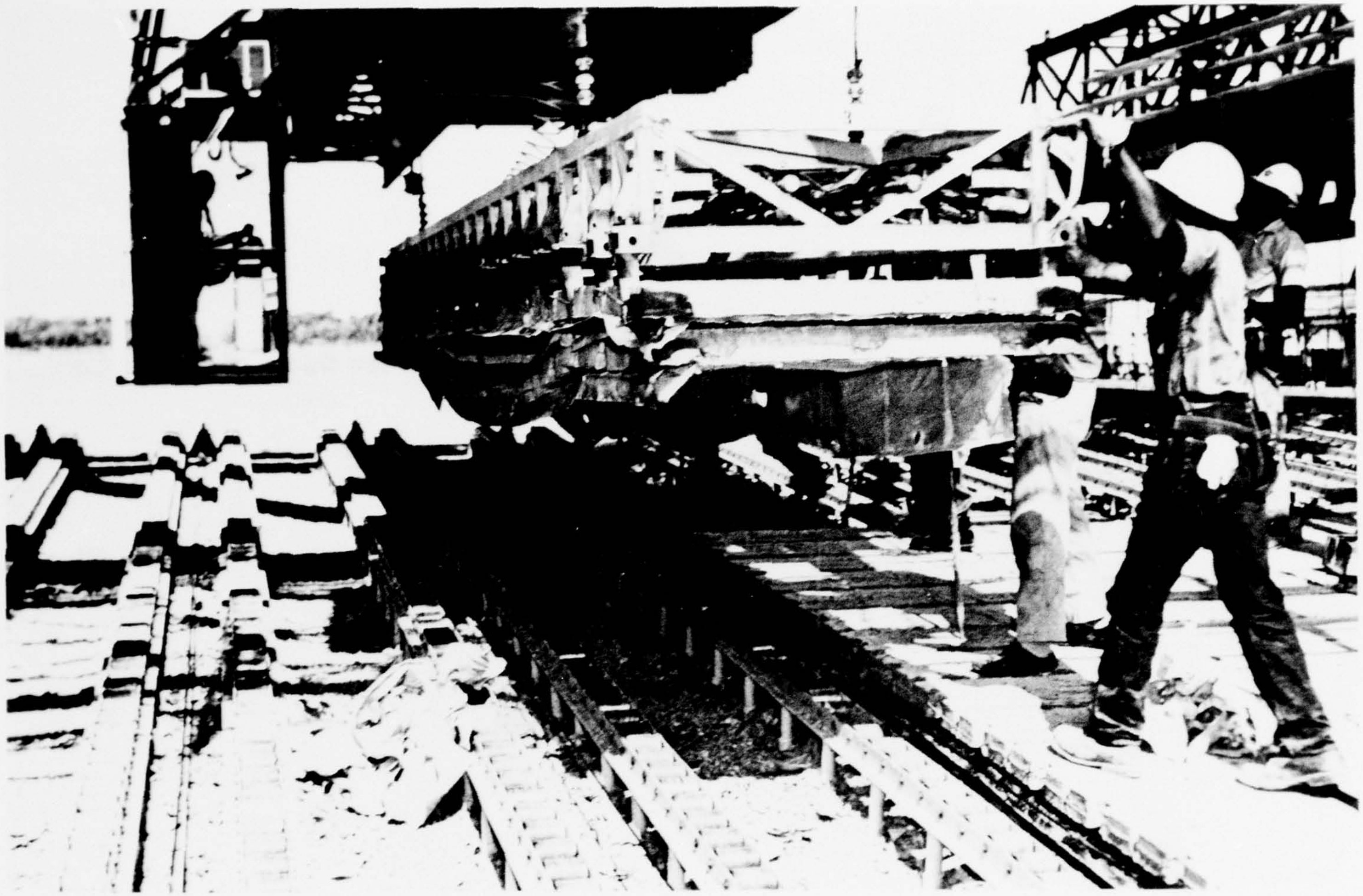

Photo No. 6

Mattress squares with filter cloth being placed on the deck of the sinking plant by the two-square pick-up frame.

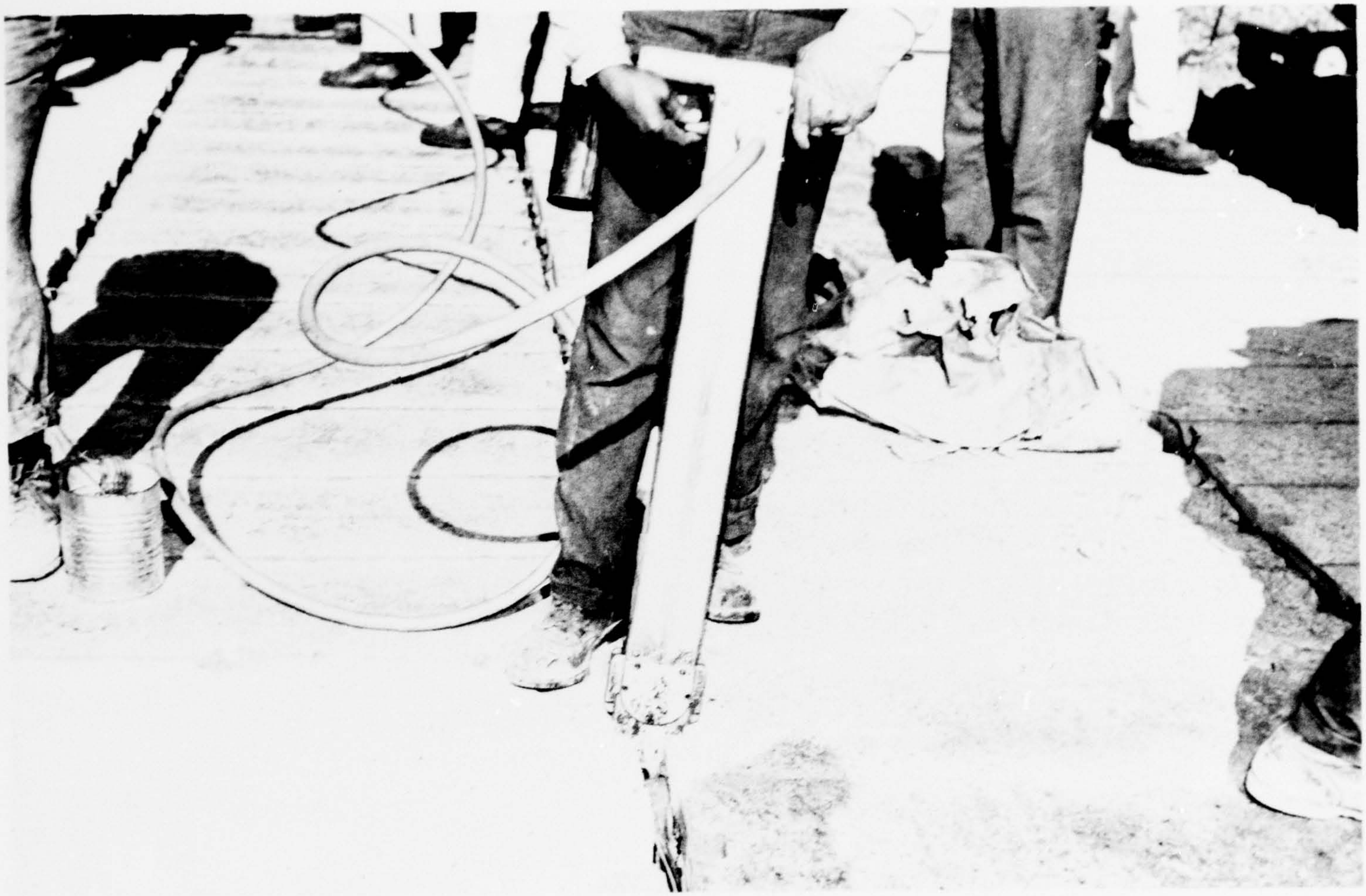

Photo No. 7

Automatic tying tool being used to make ties between mattress squares with filter cloth.

Photo No. 8

A full mattress consisting of the experimental squares with filter cloth being launched from the sinking plant.

Photo No. 9

Filter cloth with 1/4-inch cords sewn on top as a bonding device. Note that the cloth strips lie flat with no folds or creases present.

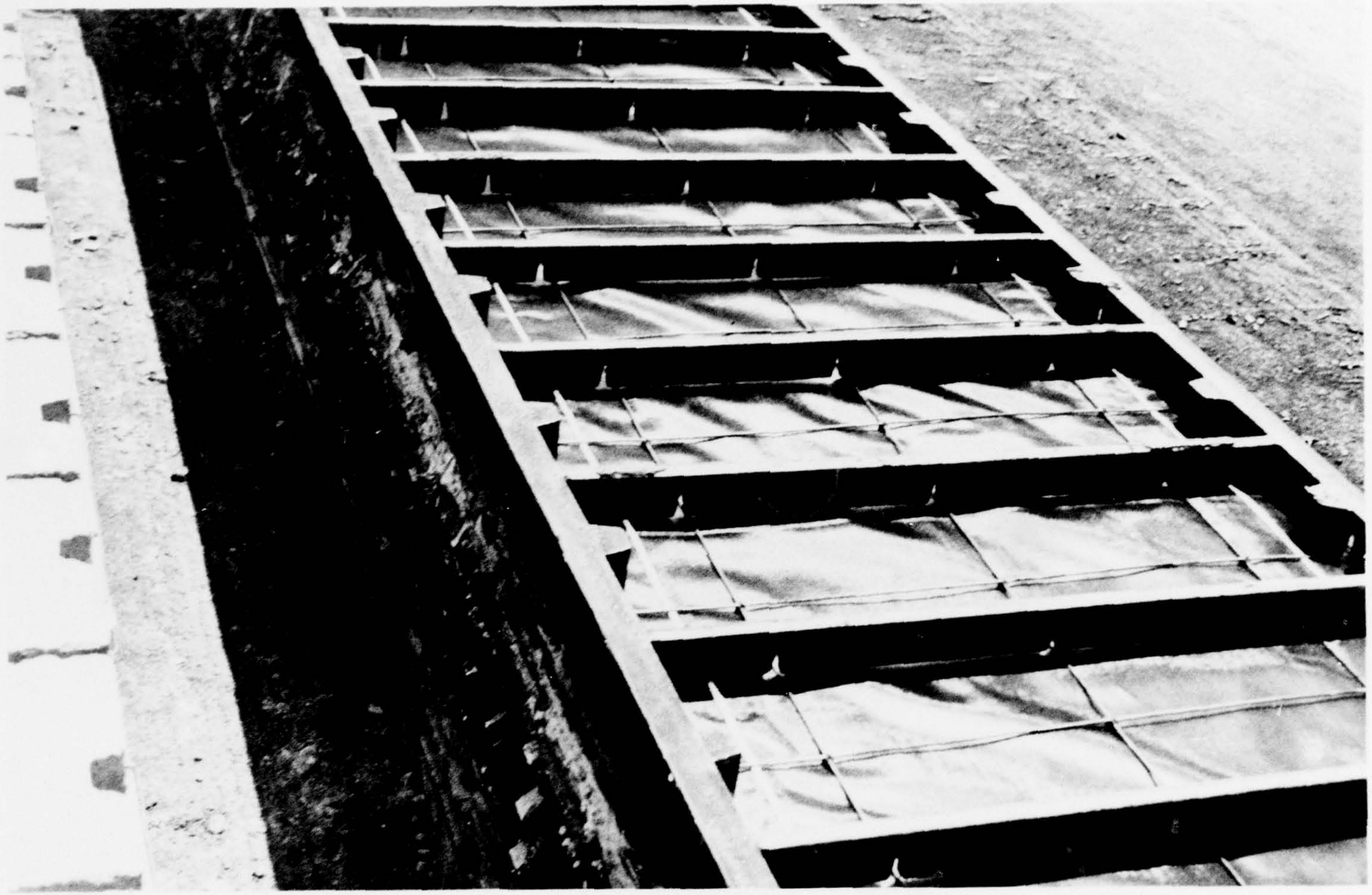

Photo No. 10

Mattress forms in place on the filter cloth with 1/4-inch cord in preparation for placing concrete.